SCIENTIFIC ARTICLE

Biomechanical Analysis of the Modified Kessler, Lahey, Adelaide, and Becker Sutures for Flexor Tendon Repair

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Purpose To compare the biomechanical properties of the modified Kessler, Lahey, Adelaide, and Becker repairs, which are marked by either a locking-loop or a cross-lock configuration.

Methods Ninety-six lacerated porcine flexor tendons were repaired using the respective core suture and an epitendinous repair. Biomechanical testing was conducted under static and cyclic loads. Parameters of interest were 2-mm gap formation force, displacement during different loads, stiffness, maximum force, and mode of failure.

Results The meaningful gap formation occurred in all 4 repairs at similar tension loads without any significant differences. Maximum force was highest in the Becker repair with a considerable difference compared with the modified Kessler and Lahey sutures. The Adelaide repair showed the highest stiffness. Overall, the displacement during cyclic loading demonstrated similar results with an exception between the Lahey and the Adelaide repairs at 10 N load. Failure by suture pull-out occurred in 42% in the modified Kessler, in 38% in the Lahey, and in 4% in the Adelaide repairs. The Becker repair failed only by suture rupture.

Conclusions The results of our study suggest that the difference between the 4-strand repairs with a cross-lock or a locking-loop configuration is minor in regard to gap formation. A strong epitendinous suture and the application of core suture pretension might prevent differences in gapping. However, the modified Kessler and Lahey repairs had an inferior maximum tensile strength and were prone to early failure caused by the narrow locking loops with their limited locking power.

Clinical relevance We suggest that surgeons should use pre-tension in repaired tendons to improve gap resistance and should avoid narrow locking loop anchoring to the tendon. *(J Hand Surg Am. 2015;■(■):■−■. Copyright © 2015 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words 4-strand repair, hand, reconstruction, suture, tendon.

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PURPOSE

Many different kinds of suture techniques have been introduced to pursue the aim of early active mobilization.[1,2] The postoperative treatment is of great importance in order to avoid restricting adhesions and to gain full excursion at the end of therapy.[3,4] To allow such a beneficial mobilization, a high−tensile strength repair is required. In recent years, suture techniques containing multiple core strands and different locking configurations have been described to achieve a reliable

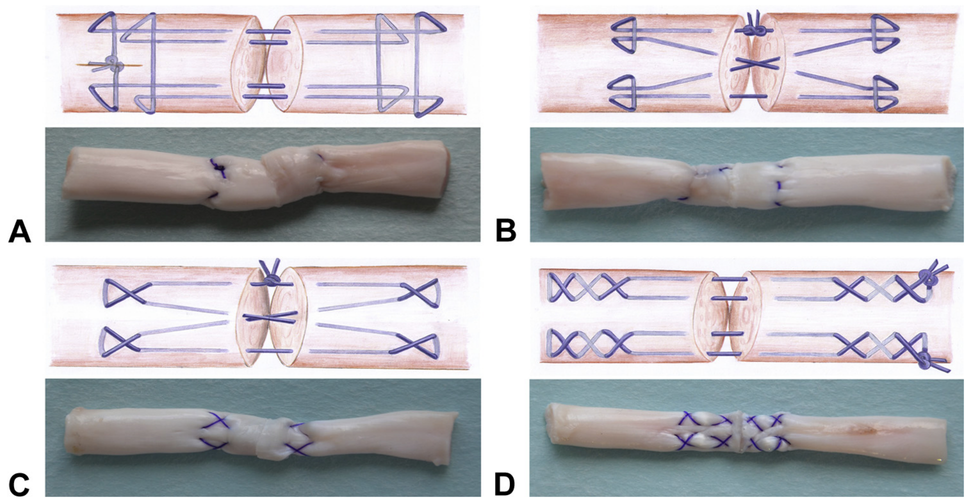

FIGURE 1: Illustration of the different 4-strand repairs. **A**, The modified Kessler suture above and a porcine flexor tendon repaired in the same technique below.[7] **B**, Lahey suture.[8] **C**, Adelaide suture.[9] **D**, Becker suture.[12]

repair strength.[5] Despite an increasing knowledge about the biomechanical behavior of such sutures, there is no consensus about the ideal technique,[1,6] and surgeons encounter a growing number of different repairs. The purpose of this biomechanical study was to analyze and compare the modified Kessler,[7] Lahey,[8] Adelaide,[9] and Becker repairs[10–12] regarding their primary tensile strength. These techniques mainly vary in their locking configuration, and we hypothesized that there would be a significant difference in gap formation force, stiffness, and displacement or maximum force between the repairs.

MATERIAL AND METHODS

Specimens

For this study, 96 fresh-frozen porcine flexor digitorum profundus tendons were used. Porcine flexor tendons have similar biomechanical properties to human flexor tendons and are frequently used for biomechanical studies.[13] Tendons from the forelimb were dissected between the A2 and the A4 pulleys.[14] All tendons were measured to ensure equal sample size. Tendons with deviating diameter or defects were excluded. Harvested tendons were stored inside saline-soaked gauzes and deep-frozen at −20°C. Before testing, tendons were thawed at room temperature for 12 hours and a scalpel was used to carefully create a defect in the middle of each tendon. Throughout testing, tendons were kept moist using saline spray to avoid desiccation.

Repair and material

Tendons were randomly assigned to 1 of 4 groups with 24 specimens per group. Group 1 tendons were repaired with a 4-strand modified Kessler suture (Fig. 1), in which the knot is buried inside the tendon.[7,15] The knot lies in the transverse component of the suture, and the suture is anchored with 8 locking loops. Tendons of group 2 were repaired with a 4-strand Lahey repair.[8] The Lahey suture is a cruciate repair with 8 locking loops. Tendons of group 3 were repaired with a 4-strand Adelaide suture (also known as cruciate cross-stitch locked repair or locked cruciate repair).[9] The Adelaide suture is a cruciate repair with 4 cross-locks. Tendons of group 4 were repaired with a 4-strand Becker suture (also known as MGH repair).[12] Twelve cross-locks can be found in the modified Becker suture, which are either exposed or embedded (Fig. 2). A core suture tendon purchase of 0.7 cm and a 10% shortening was used for all repairs to ensure the best tensile strength.[16–18] Three consecutive throws were performed for the core and peripheral suture knots. Anchor configuration was either a locking-loop (modified Kessler and Lahey) with a size of 1 mm or a cross-lock (Adelaide and Becker) with the corresponding size of 2 mm (Fig. 2).[14,19,20] Each repair was combined with a peripheral suture (Fig. 3). The epitendinous suture was a running locking suture with 2-mm tendon purchase, slight tension, which crossed the repair zone between 8 and 9 times. For all core sutures, a 3-0 polydioxanone (PDS, Ethicon, Somerville, NJ) was used, and for all peripheral sutures, a 5-0 polydioxanone. Polydioxanone is a monofilament synthetic absorbable suture material. The tendons were repaired by a trained orthopedic surgeon (MCJ) experienced in tendon repair techniques.

Biomechanical testing

Tests were conducted using a mechanical testing machine (Z020; Zwick/Roell GmbH, Ulm, Germany) and